The Agricultural College

EXTENSION BULLETIN

VOLUME III DECEMBER 1907 NUMBER 4

THE FORMATION OF THE SOIL

By ALFRED VIVIAN

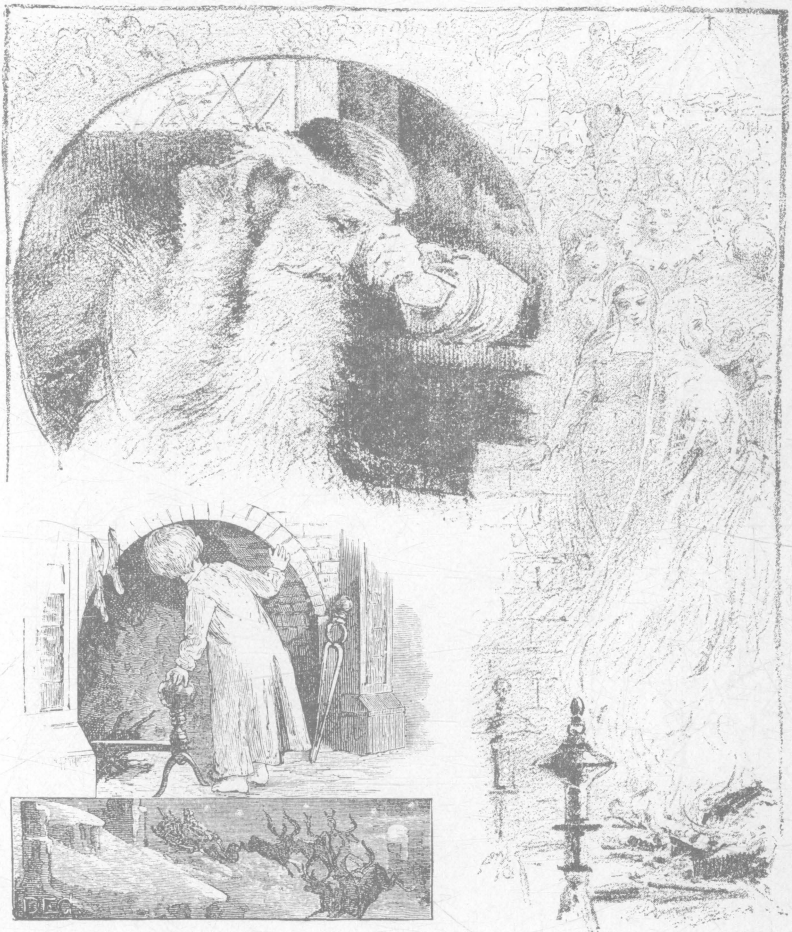
PROFESSOR OF AGRICULTURAL CHEMISTRY

Dear Santa—I write in great haste just to say
I'll help see that the accident's righted today.

PUBLISHED MONTHLY BY THE OHIO STATE UNIVERSITY

COLUMBUS

Entered as Second-Class Matter, November 17, 1905, at the Post Office at Columbus, Ohio, under Act of Congress, July 16, 1904



You'll know the fat stocking he was to have had
Is deep in the sea and poor Santa is sad."

SANTA CLAUS' PETITION

Dear Children—I write in great haste just to say
I've met with an accident coming this way
As Christmas is near, and I've so much to do,
I really must beg a slight favor of you,
And, unless I mistake, the small folks of this nation
Will spare poor old Stanta great mortification
By setting about with their might and their main
To see that the accident's righted again
You know, I suppose, that the distance is great
I travel each year, and for fear I'll be late,
I whip up my reindeer and make each good steed
Go prancing along at the top of his speed
This year my big sleigh was as full as't could hold,
I wrapped me up warm—for the weather was cold—
And started once more on my gay Christmas tour
With lightest of hearts, you may be very sure
Hi! How the bells jingled and mingled in tune!
I bowed to the stars and winked to the moon
I found myself crossing the great open sea,
With dolphins and merchildren gazing at me,
I bent a bit over the side of my sleigh
To wave them a hand, when—ah, me lackaday!
A stocking crammed full to the very small toe
Fell over the back to the sea down below,
And there the merchildren made merry ado
With toys I had meant for some dear one of you
So this is my accident, and I would ask—
I know you won't deem it a troublesome task—
That if you should see some poor child with no toys
Upon Christmas morning, dear girls and dear boys,
You'll know the tat stocking he was to have had
Is deep in the sea and poor Santa is sad,
And see that the accident's righted, because
'Twill be a great favor to

Yours

SANTA CLAUS

Julia M Lippmann

THE FORMATION OF THE SOIL

BY ALFRED VIVIAN, PROFESSOR OF AGRICULTURAL CHEMISTRY.

One could scarcely imagine any subject for discussion more commonplace than that of the soil. Nor could one think of anything which would be less likely to prove interesting to the careless observer. We are accustomed to think of the soil as merely "dirt," a thing to be shunned as far as possible, and kept hidden from sight. Perhaps you will not think the soil worthy of interest and study, but did you ever stop to think that without the soil we could not be living in this world today. The food which you eat could not have been produced if there

"Underneath all soils are found solid rocks."
"Deep valleys are worn into the surface of the earth, and the fine material is carried away to form a soil at some other place."

was no soil, for the plants which make the food for animals, in their turn derive all their nourishment from the soil. So, you see the soil is after all very important to mankind.

We are so familiar with the soil as it now exists that most of us do not stop to think that it was ever anything different, but it has really

* This article appeared in the Extension Bulletin for January 1907. There have been so many calls for it that it is necessary to republish it.

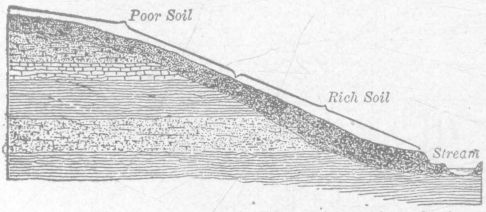
taken a long time for Nature to form what we call the soil, and in doing so she has employed the wonderful agencies about which something will be said in this article. Some one has defined the soil as "that portion of the earth at or near the surface, which consists largely of fine particles." And again it has been described as that part of the earth into which the plants send their roots and from which they take much of their food. Well, if the soil is the portion of the earth at the surface, what is below the soil? Most of you know that if you dig down deep into the soil you will come to solid rock. Sometimes rock is reached a few inches below the surface, and again you must dig many feet before you come to it, but sooner or later you are sure to find a bed of stone. We learn therefrom this first interesting fact that underneath all soils are found solid rocks.

Now, if you were to examine a sample of soil with a strong magnifying glass or a microscope, you would find that it is largely made up of very fine particles of rock. Mixed with these particles is a much smaller quantity of black material which is called organic matter, or sometimes humus. A little closer examination will show that the organic matter is simply the remains of plants which have formerly grown upon the land, and which have partially decayed or rotted in the soil. Take a small quantity of a black soil, heat it in the lid of a baking powder can, and see if the odor that come off is not very much like that you notice on heating bits of leaves in the same way.

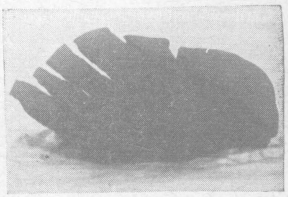
We find then that the soil is composed of small particles of rock mixed with the remains of former plants, and that by far the larger part consists of these rock particles. This suggests the thought that the soil has been formed from the solid rocks such as are found beneath it, and this, indeed, is what the men who have studied the subject have found to be true.

Geology teaches us that at one time all the surface of the earth was solid rock. At that time there was nothing like what we now know as the soil. These rocks contained all the constituents necessary to make a soil and all the substances which the plants use as food with the exception of the element nitrogen. This plant food, however, was not in forms in which the plants could use it. Suppose you had a sack of wheat. You know that there is plenty of food there to nourish you for some time but it is not in a very good form to eat so long as it is in the whole wheat kernel. One of the first things you would do would be to grind it to a flour. And that is one of the first things that Nature does in preparing the food for plants; she grinds the rocks to flour. In other words the first process in the formation of a soil is the pulverization of the rocks.

Nature uses several methods to bring about the grinding or pulverization of the rocks. The first of these is change of temperature, or heat and cold. If you examine a piece of granite you will find that instead of being a simple rock it is composed of different minerals cemented together. Now these minerals are differently affected by heat and cold. You know that most substances expand when heated. The



Showing movement of soils from higher to lower levels.



The effect of freezing on rock.

amount of expansion varies for the different minerals in the granite and as a result the effect of change in temperature is to separate the minerals, thus breaking the rock into smaller pieces.

If you look carefully at any piece of stone you may pick up you

"Running water grinds off the surface of the stones slowly but surely."

will find numerous cracks and openings in it. These cracks become filled with water and in the cold weather the water freezes. You know when water turns into ice it expands with great force and consequently when the water in the cracks freezes it tends to break the stones into pieces. If you have ever known water to freeze in a bottle or jug you

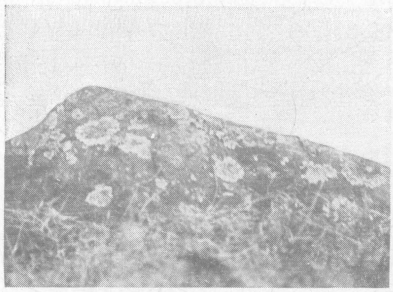
know what force it exerts and from this you can see how easy it would be for the ice to break bits of stone off the surface of larger rocks.

More important than either of these factors, however, is the action of running water. You would hardly think that such a soft substance as water would do much grinding, but water running over stones grinds off the surface slowly but surely. If the stream is swift enough to carry along particles of sand or stone the grinding takes place more rapidly. A rapid mountain stream, for instance, tumbles the boulders along, causing them to rub against each other until they are ground to powder, and at the same time the bed of the stream itself is worn away. In this way deep valleys are sometimes worn into the surface of the earth and the fine material is carried away to form a soil at some other place.

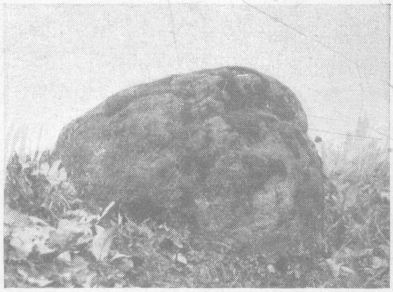
Another agency which helps to grind the rocks is moving ice in the form of glaciers. At one time all of the northern part of our country was covered by a thick sheet of ice. This immense glacier pushed its way slowly down from Canada. As it moved south it carried with it large quantities of rocks, grinding them against each other until they were reduced to particles of various degrees of fineness. Later when the climate became warmer the ice melted and this rock material remained behind to become a part of our soils. So you see there are a number of ways in which the rocks are ground to smaller and smaller fragments until they become as fine as the particles in what is called soil

But a soil produced by mere grinding of the rock alone is not suitable for the growth of farm crops If you grind your wheat into flour you must still further prepare it before it is fit for food. In the same way the food in the rocks must be prepared for the plants. We say that the food must be made "available" to the plant, or in other words it must be made soluble so the plants can absorb it through the roots. Water is important in bringing about this change also. Pure water will not dissolve much of the rock, but the water which falls on the soil contains carbonic acid gas taken from the atmosphere, and water containing this gas will dissolve much larger quantities of the rock minerals. The oxygen of the air also helps to make the plant food available. You will see, then, that at the same time the rock is being ground its nature is being changed so that it is more readily dissolved.

These processes so far described combine to make the plant food in the rocks available, but it has been found that the mineral matter alone cannot support plant life. A soil to be fertile must contain nitrogen as well. All the nitrogen in the soil came originally from the atmosphere. The air is four-fifths nitrogen, but it is in a form in which most plants



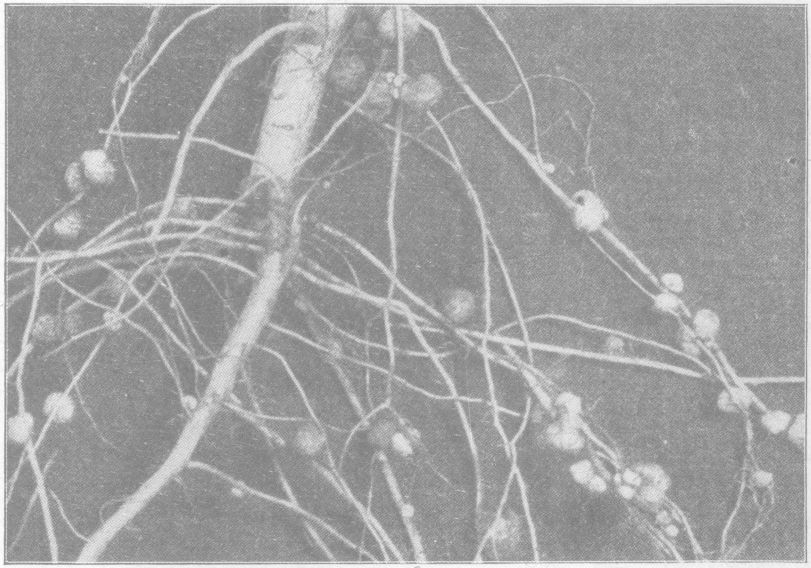
Lichens on Granite Rocks



Moss on Granite Rocks

"Vegetation begins with the very simplest forms of plants, svch as lichens and mosses."

cannot use it. Before it can serve as a plant food it must be combined with oxygen to make nitrate nitrogen. A little of this is formed in the air during electrical discharges and is carried into the soil by the rain water. This amount, though very small, is probably sufficient to enable plant growth to begin.



Nodules on the Roots of Cowpeas

Clover, alfalfa, and sweet clover have much smaller nodules.

Vegetation begins with the very simplest form of plants, such as lichens and mosses, and is, of course, very scanty at first. These plants on dying become a part of the soil, all of the plant nutrients used by them being thus returned. Food that has once been used by plants is very readily made available to succeeding crops through the process of

decay. The soil is now able to produce a larger crop, as it contains the plant food in the previous growth in addition to that added through the agencies detailed above. In this way the growth gradually becomes more abundant. The plants upon decaying give rise to humus, and this increases the fertility of the land both by being a source of plant food and by increasing the water-retaining power. Humus is a very important factor in fertility. During the decompositions of the plants, acid substances are formed which act upon the rocks in such a way as to make more of the plant food available. One of the products of decay or fermentation is carbonic acid gas, and this is dissolved in the soil water, and this gas-containing water is an important help in disintegrating the rocks.

As the nutritive materials increase from these various causes the lower and simpler forms of plant life are gradually replaced by those which are more highly organized. With the advent of plants, like our common crops, which bear roots other factors in the formation of soils are introduced. The roots secrete an acid substance that has a solvent effect on the mineral matter of the soil, and assist mechanically in breaking down the rocks. All are familiar with the tremendous force exerted by plants in breaking apart rocks and stones if once their tender rootlets obtain a foothold in a crevice. The roots penetrate the soil sometimes to great depths, and, as they decay after the death of the plant, they leave little channels in the soil which serve to carry down water laden with carbonic acid, as well as to introduce the oxygen of the air, that, in its turn, is a factor in bringing about chemical changes in the soil, which assist in making plant food available.

Sooner or later in the process of soil formation, plants of the pulse family (leguminous plants) such as clover, vetches, lupines, etc., are introduced. If you dig up some of these plants you will find little nodules or tubercles on their roots. These nodules are the homes of numerous bacteria, which enable the plants to derive part of their food from the nitrogen of the atmosphere. This peculiar property of leguminous plants is of great importance, for it is undoubtedly Nature's principal method of increasing the supply of nitrogen in the ground. The nitrogen compounds accumulated by these plants eventually become a part of the soil through their decay, thus adding to its fertility

It will readily be understood that the various agencies concerned in the formation of the soil do not act separately nor necessarily in any such order as that in which they have been discussed. As a matter of fact all the processes described take place simultaneously. The lower plants do not wait for the rocks to be pulverized, for we see such organisms as the lichens growing on rocks from which one would think it

"Lakes and ponds are gradually filled up and in time become fertile fields."

impossible for them to obtain food. If the lichen is removed, grooves or furrows will be found on the surface of the stone, due to the action of the plant. Nor are all soils formed directly from the original rocks, for one of the effects of weathering, etc., is to separate such rocks as the granites into simpler substances, with the result, for example, that

Nature's method of increasing the humus and soil fertility. Notice the rotten log and the leaves decaying, thus returning plant food to the soil.

huge deposits of limestone are formed in one place, and in another whole hills of sandstone.

The soil is almost constantly moving, for some of the same agencies which form soils are continually carrying them away. Running water grinds the rocks, but at the same time transports the fine particles to lower levels. It cuts deep valleys in the surface of the earth and carries away the debris, depositing it at various distances from its source. Notice a stream muddied by a recent rain; the mud will be deposited somewhere to help form a soil. The soil is always moving from a higher to a lower level, consequently, it is thinnest at the top of a hill and deeper in the valley. Lakes and ponds are gradually filling up and in time become fertile fields. If the pond is largely filled by the remains of the plants which have grown on it a humus or peaty soil is formed.

The important lesson to be learned from a study of the origin of the soil is, that Nature undisturbed has many ways of adding to the supply of available plant food in the soil. The various forces which have been under discussion have all tended to change more and more of the food into forms that can be assimilated by the plants so that the amount of vegetation which the soil can produce has been constantly increasing. Under natural conditions this growth is not removed from the ground, but is again made available, so that the land is constantly increasing in fertility. It will thus be seen that the fertility of the virgin soils is the result of accumulations due to a variety of forces acting doubtless through countless ages, a period during which practically nothing has been removed from the soil while much has been added to it.

Man, on the contrary, has reversed this process and while adding little to the soil has removed much from it. Through the constant harvesting of crops and by leaving the ground bare and exposed to the action of the elements, he is rapidly depleting Nature's store of food and the yield steadily becomes smaller.

This study of the formation of the soil then suggests two things that the farmer can do to prevent the exhaustion of the fertility. The first is to so treat the soil as to assist and hasten nature in the process of converting the plant food into available forms by means of good tillage. The second is to return to the soil by means of manure and fertilizers an amount of plant food equivalent to that removed by the crop.

SOIL MAKING

Kinds of Soil.—What is the difference between sand and gravel? What is the shape of a grain of sand? Of a pebble? What is dust? Dirt? What are boulders? What is the difference between dust and mud? What colors have you seen in clay? Where do we generally find clay? Which is more useful, sand or clay? What becomes of the plants that die? What is leaf-mould? Why do farmers often plough grasses into the soil? What is the color of the richest earth you have seen? Which allows water to pass through it more readily, sand or loam? Do plants ever grow upon bare rocks? In what ways do farmers make the soil richer? How deep is the loam in your garden? What is under the loam? Under that?

Distribution of Soil.—What makes water muddy? Which will a brook carry farther, fine sand or pebbles? Which can carry the greater quantity of silt, a rapid or a slow river? Which can carry the coarser and heavier? How far can a stream carry silt? What is in the beds of sluggish brooks? Rapid ones? Why do river banks sometimes cave in? Where do pebbles along the beach come from? Why are they smooth and rounded? From what is sand made? How? What makes rocks crumble? What cracks large rocks? Why are coast lines irregular? In what order does running water deposit its different kinds of sediment? In what part of a brook basin do we find the finest and richest soil? Why are bottom lands so fertile? If a muddy brook empties into a pond, where will the sediment be deposited? How are deltas formed? Of what is the soil in a delta composed?

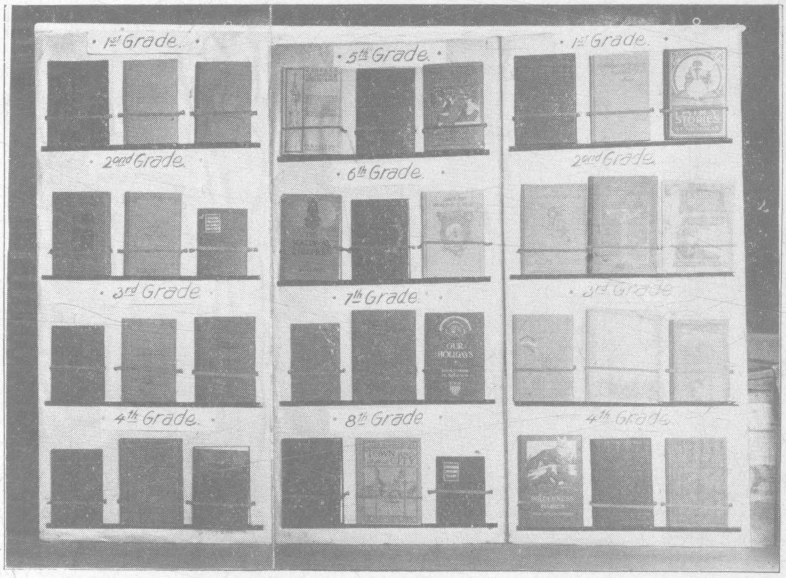
Agents at Work in the Soil.—Why do farmers plough before they sow? What is the action of frost in the soil? How deep does the ground freeze? How does nature loosen the soil each year? How far into the ground do roots penetrate? Why do we loosen the soil about roots? Where do the worms come from during or after a rain storm? Where do they live? What do they feed upon? What do they constantly bring to the surface? Do you know of any insects or bugs that improve the soil? How do bugs and worms get air underground? As we dig below the surface, does the ground appear to become warmer or colder in summer? Winter? Of what use is the sun's heat in the soil? Of what use is rain to the soil? Snow?

THE LITTLE LIBRARY

A State report, a cheap novel or two and an almanac are about as far from making a library as so much white paper; yet there are a few places where quite as little has been done toward having a few good books in the home or school.

It does not take many books to make a splendid little home or school library. Neither is it the reading of so many books that makes a great scholar. A few well selected books, well read by a thinking boy or girl, will always be a source of pleasure.

All that we see bearing beautiful colored backs, designs and



High School Course Elementary School Course

These books can be secured of the Business Manager of the Ohio Teachers Reading Circle—W. E. Kershner, Columbus, Ohio.

catchy titles are not entitled to the dignified name "book." No one can afford to fritter away time on pages which give as little of real value as a Punch and Judy show.

There is real pleasure in reading the best. Are you looking for that which has wit and humor? The best books contain the highest types of them. One wouldn't think of making a meal on whipped cream pie and tapioca pudding. Something more substantial is necessary. It is so with our reading. One needs the serious story quite as much as the humorous one.

You will never forget the Ruggles family or the spirit of Carrol Bird if you read Kate Douglass Wiggins' "Birds' Christmas Carrol." You will experience a new feeling at your Christmas dinner after reading Dickens' "Christmas Carrol." Bob Cratchet, Tiny Tim and Old Scrooge are characters that may still have living representatives. If you think you ever have reason to find serious fault with the United States government, read the story of Phil Nolan in Hale's "Man Without a Country." Mrs. Bolton's two books, "Poor Boys Who Became Famous" and "Girls Who Became Famous," will certainly inspire boys and girls to overcome what sometimes seem to be very great difficulties.

No boy fifteen years old can afford to miss the experiences of Charles Dudley Warner as told in his "Being a Boy," and no girl should come to womanhood without becoming thoroughly acquainted

These boxes containing about 40 books are lent to schools, societies, and Granges
Applications should be made to the Traveling Department of the State Library, Columbus, Ohio

with Polly in Louisa May Alcott's "Old Fashioned Girl." Boys will enjoy the pranks of Tom in the same book. Tom is not a bad boy; he is one who believes in fun and acts in harmony with his belief. Aldrich's "Story of a Bad Boy" is splendid, but it may not come up to just what you would judge from its title. "Little Lord Fauntleroy" may cost more than you think it is worth, but it is one of those excellent stories that is worth much more than the price. "The Dog of Flanders" helps one to understand that the hunger a common dog has to endure is very much like that which a boy suffers, and the cuffs and kicks are not unlike a boy's bodily punishments.

One of the very best ways to spend an evening is to be in the company of some good author and his characters who are addressing us from the printed page. It is a very quiet company, but it is a very instructive and entertaining one.

Has your school ever purchased the Ohio Pupils Reading Circle books? Or have you asked the State Traveling Library for a box of books for your school?

FOR THE ARITHMETIC CLASS

If, in preparing a mixture to prevent oat smut or potato scab, one ounce of formaline to three gallons of water is used, how much formaline will be required for one barrel of the mixture?

How many gallons do oil barrels usually contain?

In testing seed oats it was found that out of 120 grains 36 failed to sprout. What per cent. of the seed germinated?

If one-half bushel of soy beans are planted on an acre, how many bushels will be required to plant a lot 24 rods long and 20 rods wide?

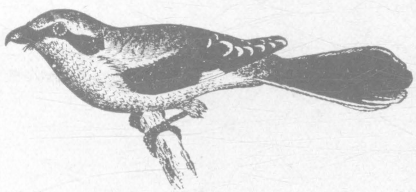
How many common tile in a rod?

Which will carry the most water, a 6-inch tile or two 4-inch tile?

How many 3-inch tile will be required to carry as much water as one 6-inch tile?

WHAT IS IT?

Let us assist you to find out the name of the plant, insect, or other specimen about which you are in doubt. Do not hesitate because what you want to ask about is common. We should become acquainted with these common things. If you will pay the postage or expressage to reach us, we will return the specimens, *if desired.*



This is the picture of a bird, the description of which was sent to this department. It is a shrike or butcher bird. This bird kills small birds and mice. It can be easily recognized from this picture.

A. B. GRAHAM,
Superintendent Agricultural Extension.

MERRY CHRISTMAS.